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REDUCING NITROGEN APPLICATIONS TO MANURED CORN: AN OPPORTUNITY TO SAVE MONEY AND PROTECT THE ENVIRONMENT

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Many of the results reported here were developed as part of Legg's dissertation research. The results have not been previously published. Funding for the research was provided by the Center for Agricultural Impacts on Water Quality at the University of Minnesota. Professors K. William Easter and Vernon Eidman of the Department of Agricultural and Applied Economics and Professor Jerald J. Fletcher of West Virginia University provided invaluable assistance throughout that research. Professor Charles Clanton of the Department of Agricultural Engineering at the University of Minnesota provided extensive assistance in developing the interview questions and estimating nutrients provided by manure. Professors Roger Higgs, William Paulson, and Arthur Peterson of the University of Wisconsin provided the 1977-86 results of the Crop Rotation Study at the University of Wisconsin Experiment Station at Lancaster. That data was used to estimate the nitrogen response function presented here. A special thanks goes to the farmers who participated in the survey and county agents Dick Walter, Charles Schwartau, Neil Broadwater, and Russell Krech for providing the contacts.

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REDUCING NITROGEN APPLICATIONS TO MANURED CORN:
AN OPPORTUNITY TO SAVE MONEY AND PROTECT THE ENVIRONMENT

Many livestock farmers in areas sensitive to nitrate contamination can reduce total nitrogen applications without adversely affecting yields. Cost savings could directly increase net returns. The reduced nitrogen applications would improve water quality. Beyond this, some farmers, armed with a better understanding of the yield/cost tradeoffs, may choose to reduce N applications to the point where small yield losses are likely to occur. These additional reductions, though possibly resulting in yield losses, would leave some farmers at least as well off financially as before.

This paper provides a self contained educational package aimed at providing farmers information which may help them improve their N management. The package includes a set of transparencies, a guide to the transparencies, and brief technical notes regarding sources of some estimates presented. The package provides material for a self contained session of about one hour for groups of farmers.

This material was developed out of the results of work aimed at understanding potential public policy effects on dairy farmers, hog operators, and farmers with no livestock. The work included interviews of 36 farmers, during which extensive information about N management decisions was gathered. The following results of the project motivated the development of this material:

1. Nitrogen applications to unmanured crops (from commercial fertilizer and legume credits) were not significantly different from estimates of economically optimal levels.

As a result, significant N application reductions to these acres would be costly to the farmer.

2. Nitrogen applications to manured corn (from manure and commercial fertilizer) were on average about 100 lbs. higher per acre than they were to unmanured corn.
3. Surveyed farmers were estimating average manure N to be substantially below research-based estimates of manure N, even after handling, storage, application, and timing losses were considered.
4. Manure is of variable quality. As a result, farmers have good reason to apply some extra N to offset the risks associated with variable manure quality. The surveyed farmers appeared to underestimate the consistency (overestimate the variability) of the N in their manure, when compared to published estimates of consistency. The result is more "insurance" applications of extra N than are apparently needed.
5. Some of the surveyed farmers used published estimates (research results) to estimate the N in their manure and managed their manure like commercial fertilizer. The results were good. These examples provide evidence supporting published estimates of the nutrient content of manure.

Conveying these results is the primary purpose of these teaching materials. Additionally, potential nutrient gains associated with upgrading manure handling facilities and equipment are noted, as are sources of more specific manure management information.

The nitrate issue motivated this package. However, the transparencies and related discussion make few references to the environmental issue. The package appeals almost exclusively to profit motives for the following reasons:

1. Extensive work aimed at understanding the specific relationships between agricultural production practices and nitrates reaching water supplies is underway. However, that understanding is far from complete. An understanding of the damages (e.g., to human health) caused by nitrates in water supplies is even less definitive. Finally, enough is known about the relationships to know that the environmental effects of a particular set of farm practices will vary dramatically from location to location. This is even true from field to field on the same farm. This implies that a credible appeal to environmental concern remain general. The purpose of this package is promoting calculable and specific changes in practices.
2. If the premise of this work (that a significant number of farmers can adopt practices which will improve profits and water quality) is sound then the direct appeal to environmental concern is unnecessary.
3. A combined appeal to the profit motive and social responsibility is likely to be confusing. Some changes in practices, convincingly motivated by appeals to concern for the environment, could not be motivated by the profit motive. The package is intended to provoke thought, leading to

practice changes several months after the presentation. Clarity about the effects of changes in N management appears crucial to the success of the package.

This entire package is based on information from and about the karst area of southeastern Minnesota and southwestern Wisconsin. The area is characterized by permeable limestone bedrock with numerous cracks and fissures. In addition, the area consists principally of ridges, valleys, creeks and rivers, and steep fields. Because of the topography, large scale farming is difficult. Farms are typically 300-500 acre mixed crop and livestock operations. The combination geological characteristics and land use patterns has resulted in elevated nitrate levels in both ground and surface waters.

Several similar areas exist throughout the United States. However, transfer of the package to other areas must be done with care. Some karst areas, such as Lancaster County, Pennsylvania, have much higher livestock intensity. Many farmers in those areas get sufficient nutrients for their crops from scraping and hauling manure. As a result, the value of added nutrients resulting from improved manure management reported here may not be valid in other geographic areas. This material does not focus on commercial fertilizer management in the absence of manure sources of N. This reflects observations of commercial fertilizer management in southeastern Minnesota. Other geographic areas, possibly including areas under lain by coarse textured soils, may present widespread opportunities to improve returns and water quality through changes in commercial fertilizer management alone.

The remainder of this material includes the text to accompany the transparency masters (placed at the end). The text is best read in conjunction with the transparencies. The text is followed by a brief set of technical notes.

We hope the material will prove useful, in whole or in part, in a wide variety of extension activities. The first step in reducing the environmental impact of nitrates is to achieve those reductions in emissions that are profitable or cost very little. This package should help some farmers consider, with some specificity, the potential on their own farms.

INTRODUCTION TO TALK ON NITROGEN MANAGEMENT

This text provides additional information and accompanies the transparencies. The transparencies are organized around the questions, or parts of the talk. For example, T2-3 is the third transparency related to the question 2.

T-1

This introduces the discussion by raising questions. These questions establish the organization for the presentation.

Recent concern about nitrates in the water, as well as the increasing need to control production costs, has resulted in a renewed interest in nitrogen applications. Several studies, including the one that generated much of the information used here, have shown that farmers typically apply more total N to manured corn than unmanured corn. Reducing these applications appears to provide farmers an opportunity to save on fertilizer and reduce nitrates reaching water supplies.

THE COMMENTS BELOW CORRESPOND TO THE QUESTIONS ON T1:

1. That most farmers don't give full credit to manure applications when applying commercial fertilizer comes as no surprise. Some estimates of actual farm applications from a survey of farmers in this area will be considered.
2. Estimates of the N provided by manure are based on figures published by the American Society of Agricultural Engineers. Are they reasonable? We will compare the results of farmers who do and don't give their manure full credit based on the ASAE estimates.

3. The N from manure varies from year to year, field to field, and farm to farm. Crediting manure for the full estimate means that some areas will receive less N than the average applied. Applying extra N to manured land reduces the chances of N shortages. However, that extra N is costly. We will consider the tradeoffs.
4. Lined storage systems, injection or incorporation of manure, and spring applications are all methods of increasing both the amount and predictability of the N provided corn by your manure. We will consider two possibilities.
5. There are several aids to help you calculate the average nutrients and the range of N your manure provides. We will tell you where you can obtain some of these materials.

SECTION 1. CURRENT N APPLICATIONS

How do overall applications of N in Southeastern Minnesota (SE MN) compare with crop needs?

T1-1

The first column of T1-1 compares per corn acre N sources for the six counties in the southeast [Goodhue, Wabasha, Winona, Olmsted, Fillmore, and Houston] with approximate needs to grow average 1987 yields in the area.[1] Conclusions: On average, applications exceed needs, even in an exceptional year like 1987.

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[1]See the technical notes (Appendix) for information on how the numbers were calculated on this and the other transparencies in Section 1.

To understand this overall excess, we need to look beyond the six county average. More detailed information was developed through a University of Minnesota study of 36 individual farms in the area. The aggregate results for those farms are shown in column 2 of T1-1. Applications are comparable to area averages, but yields, hence N needs, were higher on farms in the study. In general, though, the farms in the study appear to be reasonably representative of the area as a whole.

Even farm wide averages do not tell us where the excess applications are. Earlier work indicated that farmers were not giving full credit to legume and manure sources of N when applying commercial fertilizer, and that the excess applications are concentrated on those acres. First let's consider corn on corn on the 36 surveyed farms where no manure was applied.

T1-2 AND GRAPH

Conclusions:

1. Applications are roughly equal to needs in the absence of manure or legume sources of N.
2. Management does not differ substantially among farms of different types.

T1-3 AND GRAPH

What about applications to corn following soybeans and alfalfa? The 36 surveyed farmers, on average, credited legumes by approximately the amounts then recommended by the University of Minnesota soil testing laboratory. The table includes unmanured C-SB and C-ALF to avoid the effects of both manure and legume sources.

T1-4

This summarizes survey results relative to unmanured corn:

1. Applications (including legume credits) roughly match needs.
2. Management of N from these sources is roughly similar across farms.

T1-5 AND GRAPH; T1-6 FOR CONCLUSIONS RE T1-5

Now, how about manured corn? Applications are about 100 pounds per acre high than to unmanured corn. Again, only manured corn on corn was included to avoid combining legume and manure source effects. Quite clearly, farmers are not reducing fertilizer applications by the full amount of N provided by manure. Total N applied to manured corn on corn exceeds applications to unmanured corn on corn by 100 lbs. per acre!!

T1-7 AND GRAPH "N APPLICATIONS TO ALL CORN"

The survey showed nothing particularly shocking about N management. Possibly surprising:

- the near balance on unmanured corn.
- the credits for N provided by legumes.
- the 100 lb. difference between manured and unmanured corn.

The graph provides a visual summary of the information.

SECTION 2. CAN FARMERS CUT BACK AND MAINTAIN YIELDS?

The estimates of N provided by manure throughout this material are based upon estimates of the American Society of Agricultural Engineers (published in Livestock Waste Facilities Handbook). Are they reasonable? One way to gather some notion of the validity of the estimates is to consider the results of farmers who apply manure using the estimates.

T2-1

Here are two farmers who consider manure nutrient credits when applying fertilizer N. Both farmers operate confinement dairy operations and have liquid manure storage systems. Their yields are good.

T2-2

What about a farmer who gives little nutrient credit to his manure? This farmer lives on land that is highly productive. Two hundred bushel yields on some fields are not uncommon. However, these high yields show up whether or not the field is manured. In short, the slightly higher yields on this farm appears to reflect better land, not higher N applications.

T2-3

This farmer has an apparent opportunity to save a substantial amount of money.

T2-4

This summarizes T2-1 to T2-3. Farmers that treat manure N as if it were fertilizer (reduce fertilizer applications by about the published value of the manure) do rather well. Applying more does not appear to hurt yields, but it is expensive.

3. INSURANCE AGAINST THE VARIABILITY OF MANURE

Manure N varies from year to year, field to field, etc. Won't farmers considered on T2-1 (the careful manure managers) come up short in some years and on some fields? In other words, won't they wish they had applied some extra N as "insurance"?

In fact, they are applying "insurance". They are applying about 20 lb. extra. That appears to be sufficient.

To see this, let's consider the best available estimates of the variation in manure N (Livestock Waste Facilities Handbook, 1985).

T3-1

This considers what happens to 100 pounds of manure N that are scraped, hauled, and broadcast in the fall or winter to next spring's corn ground. Scrape and haul systems with no incorporation have the highest N losses. In addition, the N is the least predictable.

While N varies a lot, from 40-70 lbs. the average (55) and the range (40) may be surprisingly high to many. Of real importance, though, is how the variability affects yields, and hence, how much "insurance" you should buy (in the form of extra fertilizer applications).

T3-2

How does manure quality variability translate into yield variability?

To consider this question, consider a farmer who broadcasts scraped manure. The application contains, on average, 110 lbs. of N per acre. The actual N is uncertain, varying from 80-140 lbs. of N per acre.

If this farmer adds no fertilizer to the manure, the application will range from 80-140 lbs. of N; if 50 lbs. of fertilizer N are added, the total N applied will be between 130 and 190 lbs. per acre; and so on.

Again, how does this translate into yield variability? Ten years of experimental data from 80 test plots at the Lancaster, Wisconsin, Experiment Station were used to estimate the average effects of the uncertain manure quality.

While the experimental data by no means reflect conditions on all southeastern Minnesota farms, they do reflect typical conditions.

T3-3

This provides some simple averages from the data. The predicted average yields in the subsequent transparencies are those provided by a statistical study based on 800 data points. The data comes from a long term rotation study. Soybeans and alfalfa were assumed to provide 30 and 60 lbs. of N, respectively, to corn in the subsequent year. No manure was used on the test plots. The estimated response function was:

$$\text{Yield} = 88.362 + .5781\ N - .00164\ N^2$$

where N is any legume credit plus fertilizer N.

T3-4 AND GRAPH

These introduce predicted average yields, given three possible manure quality outcomes (across the top), with various applications of commercial N added to the manure (down the side).

So, if 50 lbs. of commercial N is applied, and the manure is of "poor" quality (provides 80 lbs. of N), you would expect your yield to be 136 bu. If the manure is of average (110 lbs. N) quality, yields would average 139 bu. (the maximum average yield). Similarly, high quality manure would provide the highest average yields.

If no commercial N is added, the 80-140 lbs. of n from the manure translated into average yields of 124-137 bu. That is a range of only 13 bu. Fifty pounds of commercial N brings you to the maximum yield, except when the manure is of poor quality. The remaining yield range is 2 bu. Beyond 50 lbs. of commercial N, you are left with almost no ability to affect yields. As noted earlier, though, additional applications of 100-150 lbs. of commercial fertilizers are common.

The graph provides a visual picture of the effects of choosing various fertilization levels. By choosing a fertilizer level, the farmer is choosing a bundle of average yields which depends upon the actual N in the previously applied manure.

The variability considered here relates only to the variability in manure. The variation due to weather and other factors have been averaged out. Actual yields in good and bad years could be 20-50 bu. higher or lower.

T3-5 AND GRAPHS

These materials relate prices to the yields in T3-4. T3-5 assumes corn prices of $2.20 per bu. and fertilizer prices of 0.15 per pound. The first graph retains the prices used in T3-4, while the following reflect lower (0.10) and higher (0.20) fertilizer prices, respectively.

Note that variability due to uncertain manure N can be eliminated by adding more N. The graph of T3-5 shows this most clearly. Adding 50 lbs. of fertilizer N improves average returns and reduces variability. Addition of 75 lbs. further reduces variability, but is accompanied by a small reduction in average returns (when compared to returns at 50 lbs). A move from 75 to 100 lbs. eliminates all variability related to manure quality. However, returns are lower than at 75 lbs., regardless of actual manure quality. Adding 150 lbs. simply leaves you worse off.

Fertilizer N at $0.20 increases the costs of moving from 50 to 75 lbs. per acre, leaving the 50 lbs. application clearly better. A $0.10 price makes returns at the 50 and 75 lbs. application levels equal on average. However, even with corn at 22 times the price of commercial N ($2.20 vs. $0.10) the 100 lbs. level does not provide the highest average returns.

T3-6 AND T3-7

These summarize this section from two perspectives. T3-6 focuses on adding fertilizer to manure from the perspective of average returns. T3-7 summarizes from the perspective of using commercial N as "insurance" against high losses of manure N.

4. EFFECTS OF MANURE HANDLING OPTIONS ON AVERAGE N & ITS VARIABILITY.

We all know that a variety of manure handling options and alternatives are available. A decision to invest in a storage system and related equipment (honey wagons, pumps, injectors, etc.) depends on a variety of factors in addition to the system's initial costs and the nutrient gains. These include:

- labor requirements. (How much do I dislike hauling manure every few days in the winter? How much do I dislike the thought of spending a solid week every spring and/or fall hauling manure?)
- equipment time and expense. (How costly is it to run the tractor in the winter for manure hauling? Do I or will I have the tractor available for a week every spring and/or fall to haul manure?)
- availability of cost sharing.
- environmental concerns. Smell, nearby streams, wells.

Nutrient gains alone are unlikely to justify an investment in a manure storage and handling system. However, storage systems can almost double the average N made available to crops from a given quantity of manure (when compared to traditional scrape and haul systems). In addition, storage systems increase the predictability (reduce the variability) of the N made available to crops. Here, the N provided by two systems will be compared. The comparison of a lined liquid storage system and a traditional scrape and haul system utilizes the characteristics of a typical small SE Minnesota dairy farm. (The farm was developed from the small dairies included in the 36 farm survey.)

T4-1

This provides basic information about the farm. Note that N production is similar to that on typical SE Minnesota hog operations.

T4-2 AND 4-3

These provide information about what happens to the manure N on the farm under two sets of manure handling assumptions. The assumptions are of two extremes, daily scrape and haul (S&H) and a lined liquid storage system. Examples of the lined systems are concrete pits and Slurrystores. Lined systems result in the lowest N losses.

P & K are ignored because the amounts are largely unaffected by system or other handling practice. However, if a significant part of the manure runs off the land, the P & K therein can go with it. This is much more likely with a scrape and haul system.

SPECIFIC COMMENTS ON T4-2 AND T4-3.

All numbers, including nutrient production presented in the previous transparency, are applications of estimates in the Livestock Waste Facilities Handbook. All estimates are rounded to the nearest 500 lbs.

With the S&H system, manure needs to be spread on alfalfa, pasture, etc. in the summer. If that manure is broadcast, and the land does not go into corn the following year, the N is essentially discarded. With a storage system of sufficient size (few in SE Minnesota aren't) all manure can be spread in the fall or spring on the corn ground. Hence, the 4,500 lb. loss with S&H, none with the system.

Losses prior to application (storage losses with a system) are 15-30% and 15-35% respectively. Scrape and haul losses are smaller because the % are applied to 13,500 lbs. not 18,000.

Application losses include losses in the first three days after application. These are very high with broadcast solids (15-30%). Injection essentially eliminates these losses (0-2%).

"Lost prior to crop use" is loss due to applications substantially before the crop can use the N. These are estimated to be from 5-10%, except when the applications are made very near planting time. The lined storage system is assumed to have six month's capacity, so half of the manure is applied in the Fall and half prior to planting in the Spring. Hence, 2.5-5% losses are assumed (5-10% on half and none on the other half).

The S&H manure is assumed evenly applied to corn over nine months of the year. Because only a minor portion is applied just prior to planting, all is assumed subject to 5-10% losses over the period between application and planting.

"Available to corn" is the fertilizer equivalent N that will be made available to corn from the manure. Not all will be made available in the first year. However, a farmer with a constant herd size who applies similarly each year can expect to get approximately this amount of N each year. As noted in the next section, a rotation of manure applications requires that a farmer consider current and previous two years' applications if full consideration is to be given to manure N.

While the range of N is nearly as wide with the storage system as with S&H, N from the system is proportionally less variable. This can be explained by considering average applications from the system of

123 lbs. to 60 acres (7,500/123). The range of N provided would be 90-155 lbs. per acre, rather than the 105-136 with the system.

The $900 is the savings associated with decreasing commercial fertilizer applications by the 6,000 lbs. Note that the herd size is not large: 64 dairy cows, a 120 sow farrow to finish operation, or 2100 hog finishing operation.

What about other systems? Two other commonly owned systems are earthen rather than lined liquid storage and lined bottom fed semi-solid storage systems.

The earthen storage has higher storage losses. Assuming similar application practices, injection Spring and Fall, N would range from 10,000 to 14,000 lbs. (1,500 lbs. less than liquid system).

The lined sold system has N retention characteristics similar to the lined liquid pit. Since injection is unavailable, the N saving application method is immediate incorporation. That increases losses by about 500 lbs. The range would be 11,000 - 14,500 lbs.

T4-4

This provides conclusions that can be drawn specifically from the numbers on T4-2 and T4-3. in addition to the points on the transparency, it should be noted that N does not disappear under S&H, even under the worst conditions.

T4-5

This sums up the results of the section. A storage system, whatever type it is, substantially increases the N that can be made available to crops that need it. Stored manure is also of more predictable quality than periodically hauled manure. That predictability can be increased by testing (liquid or semi-solids) and thoroughly agitating liquid.

The last two points are intended to switch the participants focus to his or her own farm. Many farmers built systems for reasons that did not include nutrients. Nearly all farmers have considered systems without realizing the effects the system would have on manure nutrients. Including nutrients in the consideration might change some decisions.

5. ESTIMATING THE NUTRIENTS ON YOUR FARM?

The final question is obvious. Fortunately there are several publications available to assist farmers estimating the nutrient in the manure. Unfortunately, estimating the range of nutrients requires a bit more diligence than computing a single estimate.

T5-1

This transparency points out what the publications will provide.

T5-2

This lists three publications. Comments on each publication are noted below.

"Utilization of Animal Manure as Fertilizer" - This publication provides all the factors necessary to compute nutrients provided by manure on a particular farm. Nutrient ranges conditional on storage and handling practices are readily computed. In addition, a worksheet provides step by step computations of the average nutrients provided, additional commercial fertilizer required, and the minimum land area needed to utilize available manure.

"Manure Management in Minnesota" provides a concise, readable description of the factors that affect or should affect manure management decisions. A very simple worksheet can be used to estimate the per acre nutrients in manure applications and the supplemental crop requirements.

The Livestock Waste Facilities Handbook includes the information in the above publications, as well as a detailed discussion of various manure handling facilities and equipment. This book will be particularly useful to those considering new or altered manure handling systems.

SUMMARY

T6-1

This transparency summarizes the discussion by repeating the questions on T1 with short comments summarizing the answers presented here.

TECHNICAL NOTES

This section describes the methods used to estimate nitrogen sources and needs. Differences between the Southeastern Minnesota and surveyed farm estimates are noted.

NITROGEN NEEDS

Needs as shown in section 1 are defined as the estimated amount of N required to obtain the average corn yield or yield goal[1] following two or more years of corn production. Needs per bushel are estimated at 1.1 pounds of N, which is the average of a rule of thumb for the corn belt (1.2) and the approximate applications recommended by the University of Minnesota Soil Testing Laboratory (1.0).

NITROGEN SOURCES

Sources of N include commercial fertilizer, biologically fixed N from previous legume crops in rotation (soybeans and alfalfa), and animal manure. Nitrogen sources are estimates of the amount of N available for growing corn, not necessarily the amount applied. For example, some manure is spread on pasture.

As a measure of commercial N applied to corn acres in Southeastern Minnesota, we used 95% of the 1987 crop year (July 1, 1986 to June 30, 1987) dealer sales of N fertilizer in the six

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[1]Average yields for Southeastern Minnesota are the 1987 averages reported in the Minnesota Agricultural Statistics. This approximates an upper limit on needs, as 1987 was a particularly good year. The individual farm fields reflect the average of estimated 1987 yields provided by farms.

counties of Southeastern Minnesota averaged over 1987 corn acres. We estimated that 5% of the N was applied to crops other than corn.

Individual farm commercial fertilizer use in actual N applied adjusted to reflect estimated losses due to timing and method of application. In practice, these adjustments were minimal. Thirty five of the 36 surveyed farmers incorporated or injected fertilizer just prior to or at planting time or side dressed after planting; all application methods with minimal losses.

Estimated N credits from legume crops are based on published estimates by the University of Minnesota Soil Testing Laboratory in 1987. The Laboratory recommended reducing N applications by 30 pounds per acre on corn after soybeans as compared to continuous corn. The application reduction following alfalfa depends on the quality of the alfalfa plowed under. We conservatively assumed that all stands rotated were of poor quality, indicating a one year application reduction of 60 pounds per acre of alfalfa rotated to corn. A reduction of 100 pounds of N the first year and 60 pounds the second year was recommended if the rotated alfalfa stand was of good quality. We assumed all soybean acres and 1/3 of the acres in alfalfa are rotated to corn in the subsequent year. The one year 60 pound credit for alfalfa was also used on the surveyed farm estimates based on discussions with farmers regarding the quality of the alfalfa stands they plowed under.

Southeaster Minnesota is characterized by intense livestock production, including poultry, dairy, beef, and hog operations. Available N from livestock was estimated as follows:

1. Livestock data for Southeastern Minnesota for 1987 were obtained from Minnesota Agricultural Statistics - 1988. Nitrogen production was estimated using per animal annual production estimates, by weight and type, obtained from the Livestock Waste Facilities Handbook.
2. Nitrogen collected in manure handling systems is based on the estimated proportion of time each type of animal is customarily confined.
3. Nitrogen handling, storage, and application losses were based upon estimates of actual manure handling practices. Proportional losses (averages and ranges), given particular practices, were obtained from the Livestock Waste Facilities Handbook.
4. Nitrogen contained in manure is generally released and becomes available over three years. We assumed that total N available to corn from current and prior year manure applications was equal to total N in the current year's application. This implicitly assumes constant livestock intensity over time.

On the surveyed farms, practices were those reported by the farmers. Nitrogen production and proportional (range and mean) losses, for given practices, were estimated as described above.

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T-1

REDUCING NITROGEN APPLICATIONS TO MANURED CORN: AN OPPORTUNITY TO SAVE MONEY AND PROTECT THE ENVIRONMENT

1. **How do farmers' actual nitrogen (N) applications to manured and unmanured land compare?**

2. **Can farmers cut back and maintain yields?**

3. **N from manure is less predictable than fertilizer N. Doesn't that require a higher application as insurance?**

4. **How do different application and storage methods affect the amount and predictability of manure N?**

5. **What aids can you use to help you estimate the N, P, and K available on your farm?**

T 1-1

N APPLICATIONS EXCEED NEEDS THROUGHOUT THE SE AND ON 36 SURVEYED FARMS

	Southeastern Minnesota	Surveyed Farms
N Sources		
Commercial Fertilizer	132	134
Legume Credits	20	13
Manure	65	59
Total Sources	217	206
N Needs		
Average 1987 Yield	139	153
N Required Per Bushel	1.1	1.1
Total Needs	153	168
Per Acre Excess	64	38

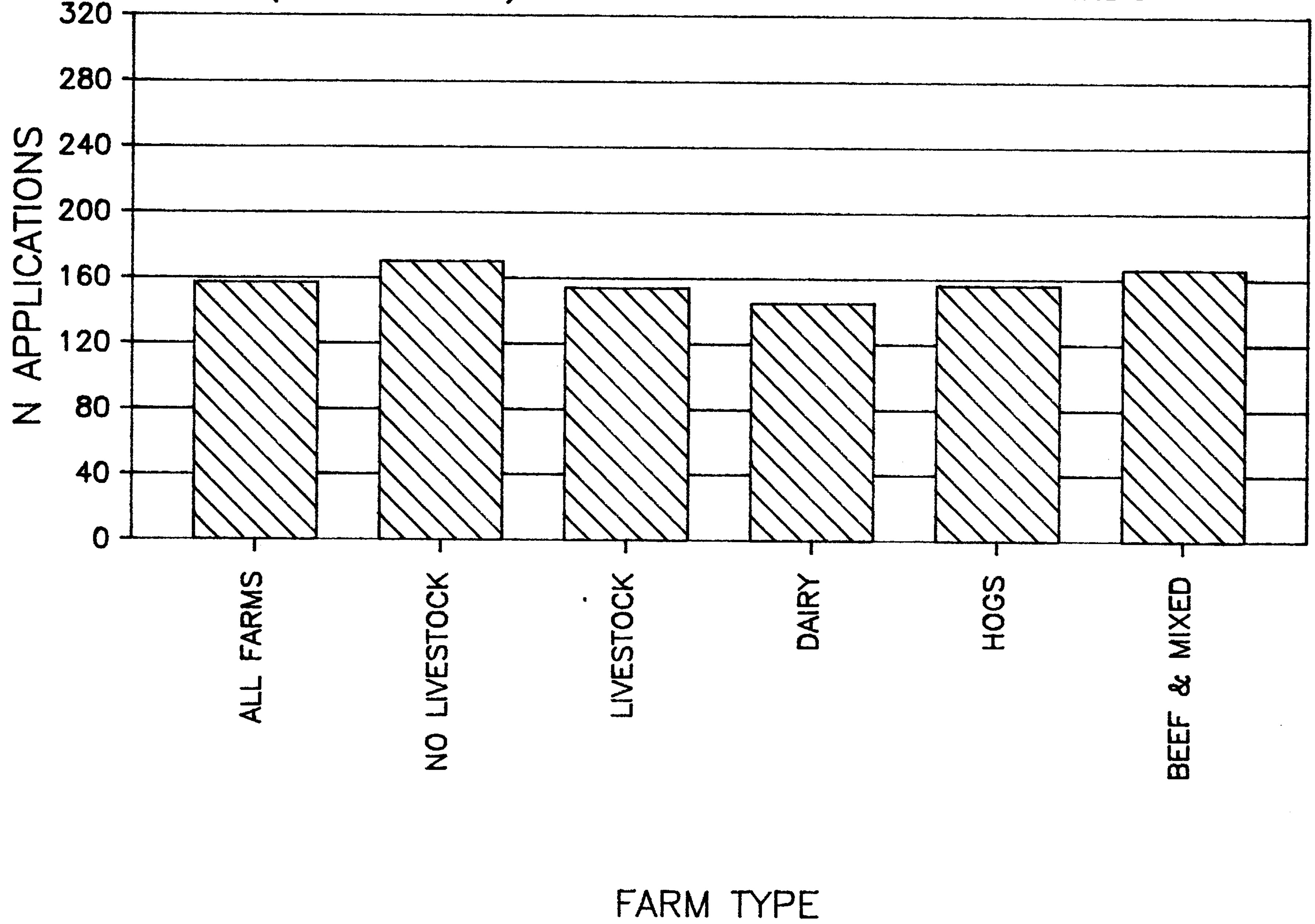
T 1-2

N FERTILIZER APPLIED TO CORN ON CORN WITH NO MANURE CLOSELY MATCHES CROP NEEDS

Average Application Per Acre:	
All farms	**157**
Farms With:	
No livestock	**170**
Livestock	**154**
Dairy only	**145**
Hogs only	**156**
Beef and Mixed Livestock	**166**
Average Needed Per Acre[1]	**168**

[1]Average needed to grow 1987 yields from T 1-1.

N FERTILIZER APPLIED TO CORN ON CORN (NO MANURE) CLOSELY MATCHES CROP NEEDS



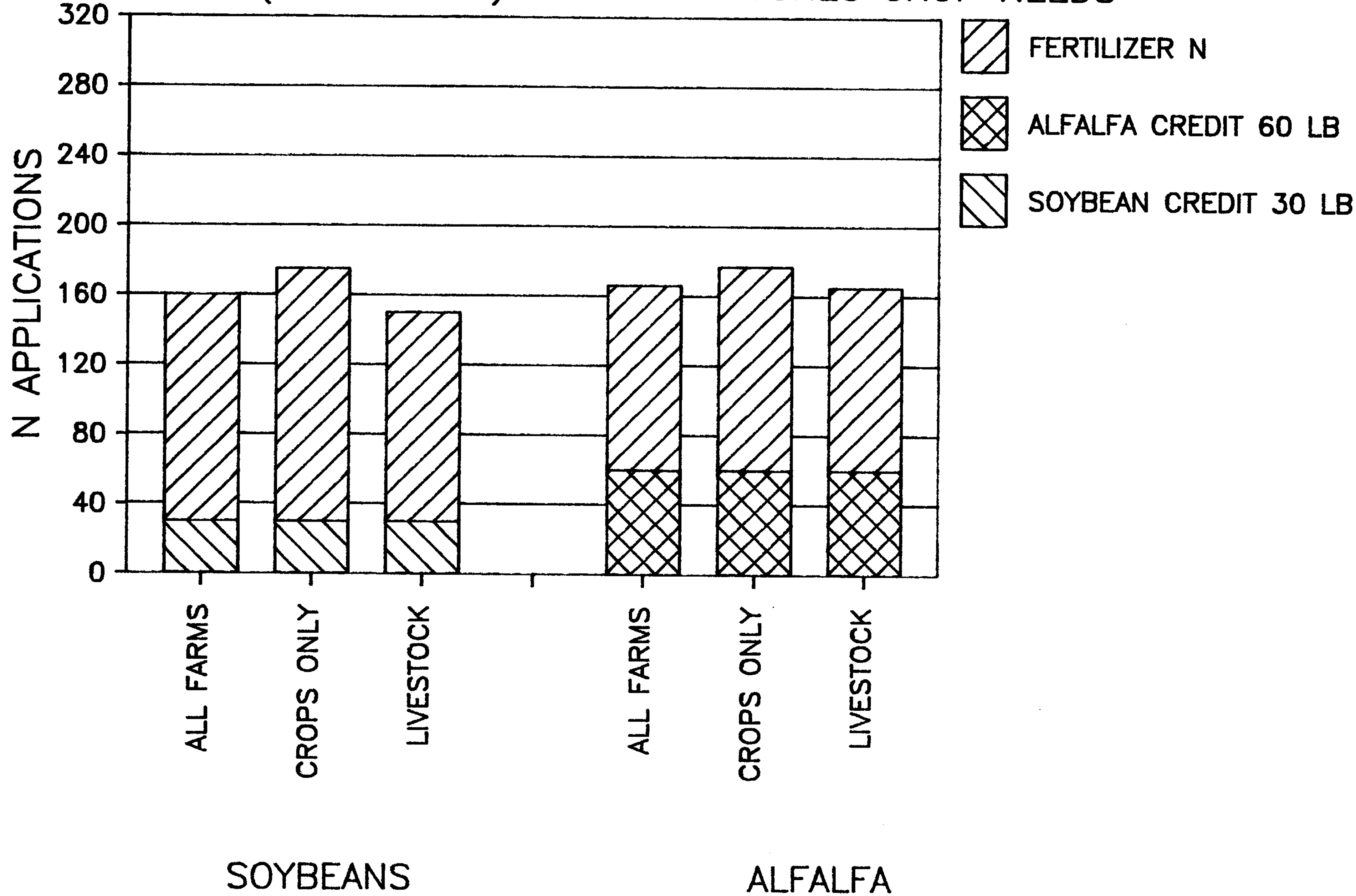
T 1-3

N APPLIED TO CORN FOLLOWING LEGUMES WITH NO MANURE CLOSELY MATCHES CROP NEEDS

	Average N From		
	Fertilizer	Legume Cr.[2]	Total
Corn-Soybeans:			
All farms	130	30	160
Farm With:			
No Livestock	145	30	175
Livestock	120	30	150
Corn-Alfalfa:			
All farms	106	60	166
Farm With:			
No Livestock	117	60	177
Livestock	105	60	165

[2]Legume credits were estimates provided by the U of MN Soil Testing Laboratory in 1988. The alfalfa credit of 60 lbs. assumes that the rotated stand was of poor quality. The estimates of N provided by the U of MN have been increased recently.

N APPLIED TO CORN FOLLOWING LEGUMES
(NO MANURE) CLOSELY MATCHES CROP NEEDS



T 1-4

- **N applications to unmanured corn roughly match crop needs in a good year (1987).**

- **Farmers generally take credit for legume sources of N.**

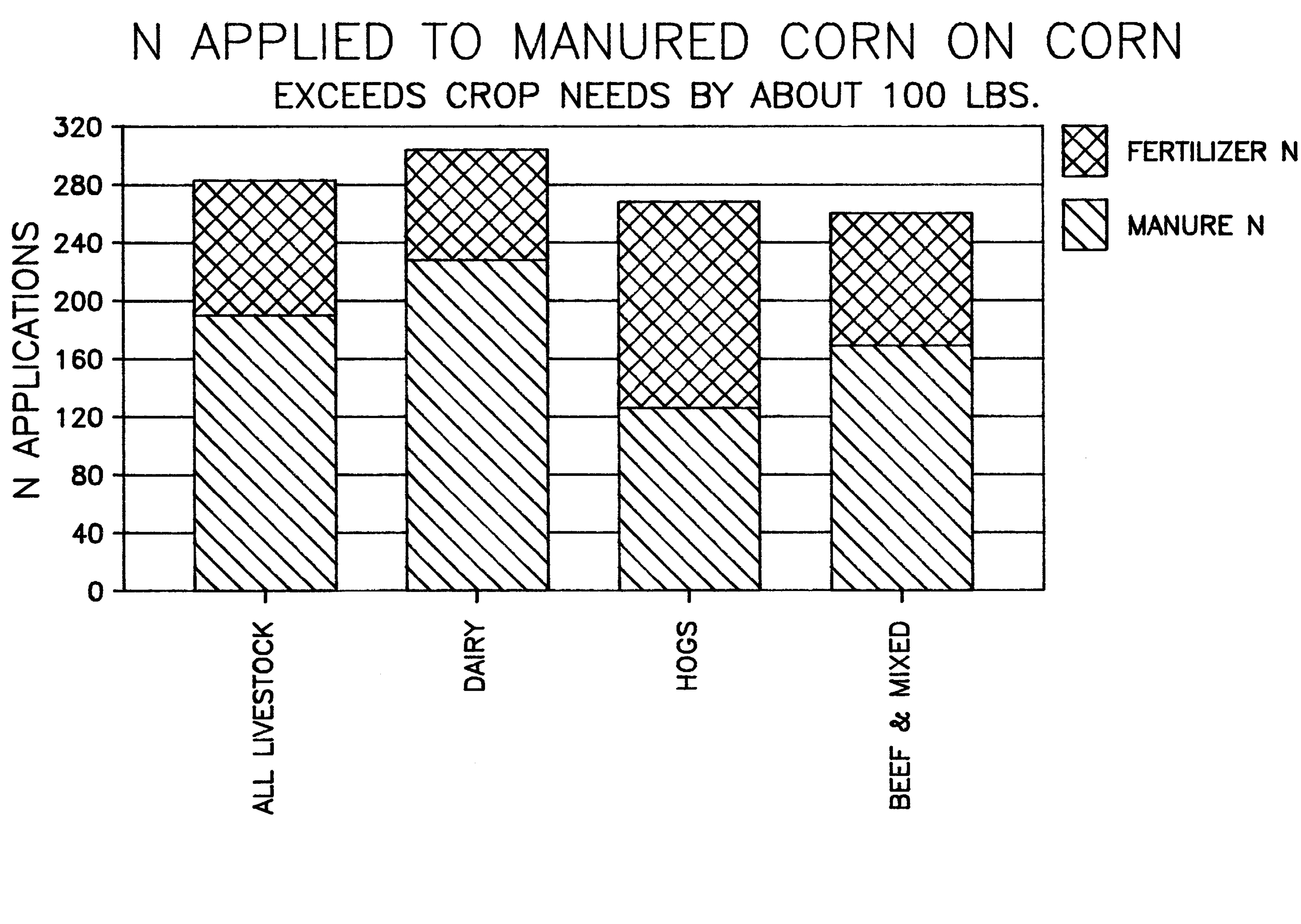
- **N applied to unmanured corn does not differ by type of farm.**

T 1-5

N APPLIED TO MANURED CORN ON CORN EXCEEDS CROP NEEDS BY OVER 100 POUNDS

	Average N Applications		
	Manure	Fertilizer	Total
Farms Wtih:			
Livestock	190	93	283
Dairy only	228	76	304
Hogs only	126	142	268
Beef and Mixed Livestock	169	91	261

Crop Needs: 168 lbs.


N APPLIED TO MANURED CORN ON CORN
EXCEEDS CROP NEEDS BY ABOUT 100 LBS.
N APPLICATIONS
320
280
240
200
160
120
80
40
0
FERTILIZER N
MANURE N
ALL LIVESTOCK
DAIRY
HOGS
BEEF & MIXED
FARM TYPE

T 1-6

- **N (manure + fertilizer + legume) applied to manured corn on corn exceeds applications to unmanured corn by over 100 lbs. per acre on surveyed farms, on average.**

- **The farmers reduce fertilizer applications to manured corn. However, the fertilizer reductions average about 100 pounds less than the average N in the manure.**

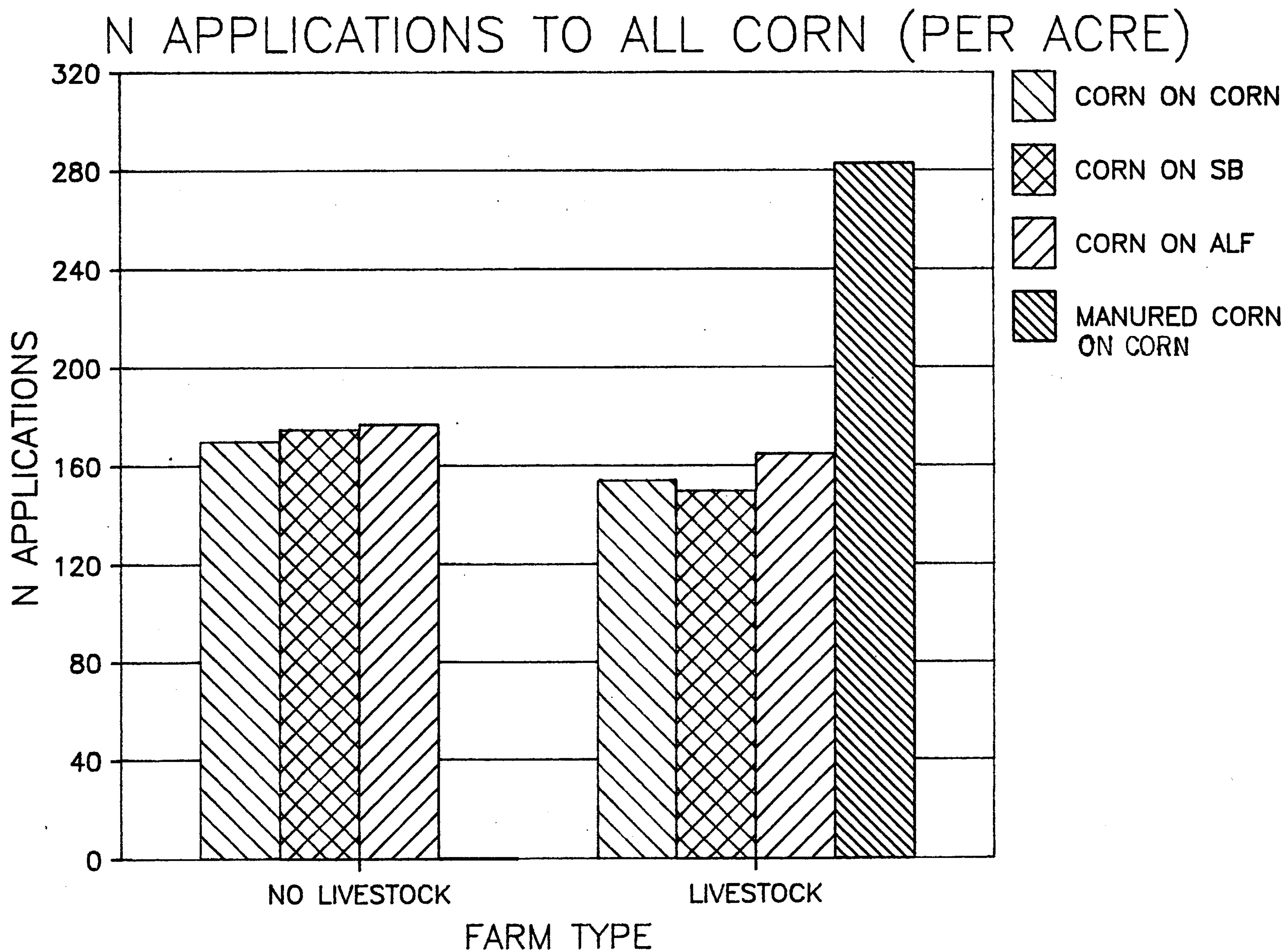
- **Total N applications to manured corn does not vary much with livestock type.**

T 1-7

CURRENT NITROGEN USE IN SOUTHEASTERN MINNESOTA

- N applications to unmanured corn are approximately in balance with crop needs.
  - No differences across farm types are apparent.
  - Legume sources are credited.

- Total N (manure + fertilizer + legume) applied to manured corn averages about 100 pounds per acre higher than on unmanured land.
  - Again, no differences among livestock types are apparent.
  - Manure sources are partially credited, on average.


N APPLICATIONS TO ALL CORN (PER ACRE)
320
280
240
200
160
120
80
40
0
N APPLICATIONS
CORN ON CORN
CORN ON SB
CORN ON ALF
MANURED CORN ON CORN
NO LIVESTOCK
LIVESTOCK
FARM TYPE

T 2-1

N APPLICATIONS TO CORN BY TWO FARMERS WHO CONSIDER MANURE NUTRIENT CREDITS WHEN APPLYING FERTILIZER N

	Farm	
(Inputs per average corn acre in 1988.)	1	2
N applications:		
Commercial fertilizer	54	60
Legume credits	23	0
Manure	112	121
Total applications	189	181
Applications to:		
Manured corn	195	183
Unmanured corn	75*	161
Yields:		
Average	150	150
1987	162	155

*Low application reflects credit for previous year manure applications.

T 2-2

N APPLICATIONS TO CORN BY A FARMER WHO GIVES LITTLE NUTRIENT CREDIT TO HIS MANURE

(Inputs per total corn acre.)

N applications:	
Commercial fertilizer	139
Legume credits	10
Manure	115
Total applications	264

Applications to:	Avg.	Range
Manured corn	339	269-396
Unmanured corn	163	136-176
Yields:		
Average	170	
1987	170	

Manure containing an estimated 8000 lbs. of N was applied to other crops. Application of this manure to corn would have provided an additional 43 lbs. of N per acre of corn on the farm. (Spreading all manure on corn may not be practical.)

T 2-3

HOW MUCH COULD THIS FARMER SAVE??

Corn acres manured	62 A.
Per acre N savings if actual N was reduced from 339 to 180 lbs. on all manured acres	159 lbs./A
N saved	9,858 lbs.

Money saved per year:

at $.10 per lb. of N	$ 985
at $.15 per lb. of N	1,475
at $.20 per lb. of N	1,970

This does not include potential additional savings of $800-1,600 if all manure now applied to other crops (8,000 lbs. N) were applied to corn.

T 2-4

- **Farmers applying 180 lbs. N (including the manure N), to manured corn are getting good yields.**

- **Yield differences probably reflect land differences.**

WHAT HAPPENS TO 100 LBS OF N IN MANURE THAT IS SCRAPED, HAULED, AND BROADCAST ON NEXT SPRINGS CORN?

15-35 lbs. is lost before application.

12-20 lbs. more is lost during and within 2-3 days of application.

4-5 lbs. more is lost if the application is in the previous fall or winter, as opposed to just before spring planting.

This leaves 40-70 lbs. (about 55, on average) for the crop.

HOW WOULD ADDING FERTILIZER TO THE MANURE AFFECT YIELDS?

If manure with 80-140 (average 110) lbs. N per acre was previously applied:

And you added:	Total N Applied
No fertilizer N	80-140
50 # fertilizer N	130-190
75 # fertilizer N	155-215
100 # fertilizer N	180-240
150 # fertilizer N	230-290

Average yields were estimated using 10 years of data from 80 test plots at the Lancaster, Wisconsin Experiment Station. The station is typical of many, but not all, farms in Southeastern Minnesota.

T 3-3

SELECTED AVERAGE YIELDS (1977-1986) IN LANCASTER, WISCONSIN

N Application	Observations	Average Yield
0	100	82
50	100	113
100	100	126
160	80	138
200	100	130
260	80	134

These yields are actual averages.

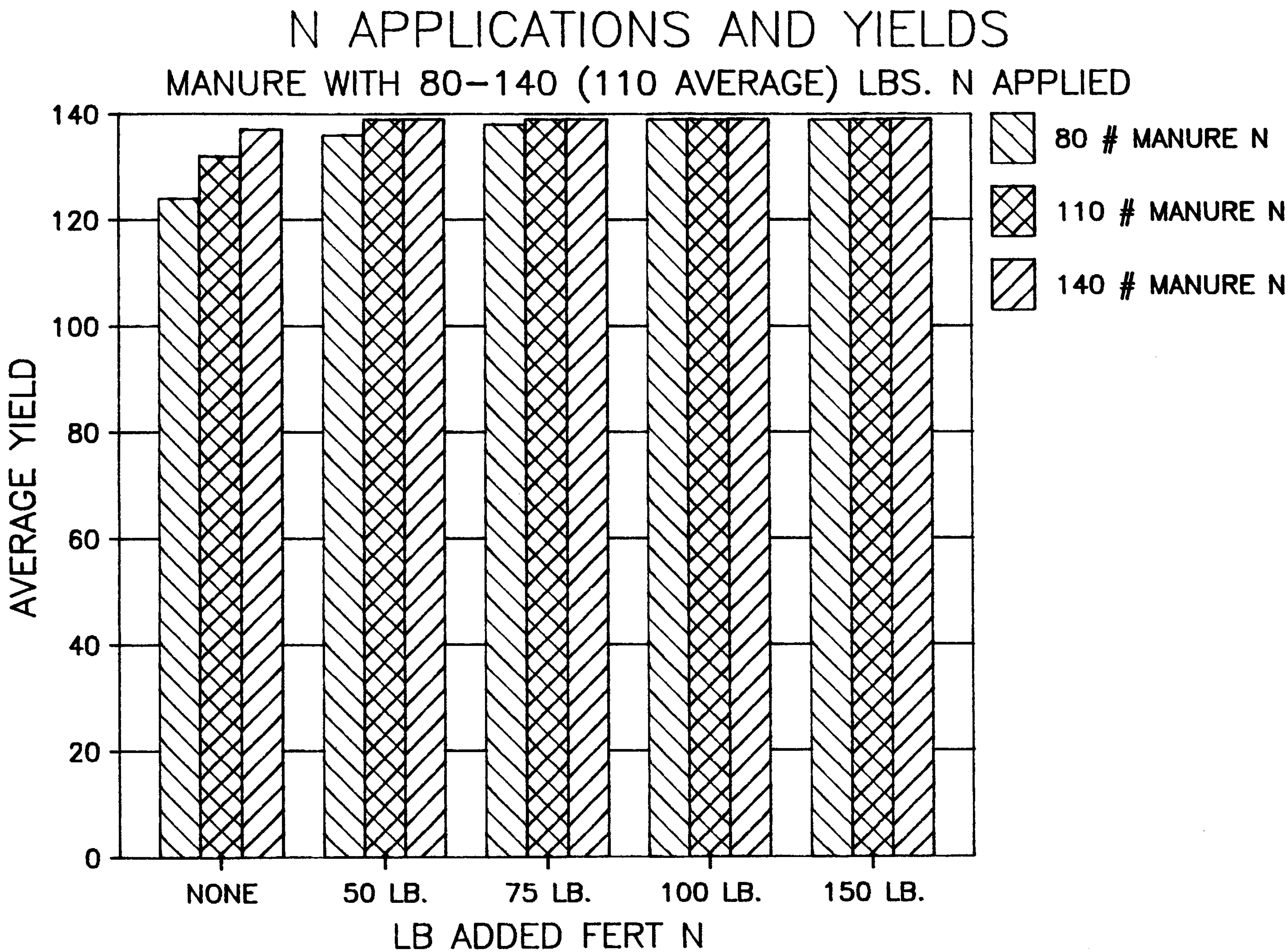
The yields shown in the following transparencies were predicted from an analysis of all the data.

T 3-4

HOW DOES ADDING FERTILIZER TO THE MANURE AFFECT YIELDS?

If manure with 80-140 (average 110) lbs. N per acre was previously applied

	Total N	Avg. Yield if Manure Has		
	Applied	80 # N	110 # N	140 # N
And you added:				
No fertilizer N	80-140	124	132	137
50 # fertilizer N	130-190	136	139	139
75 # fertilizer N	155-215	138	139	139
100 # fertilizer N	180-240	139	139	139
150 # fertilizer N	230-290	139	139	139



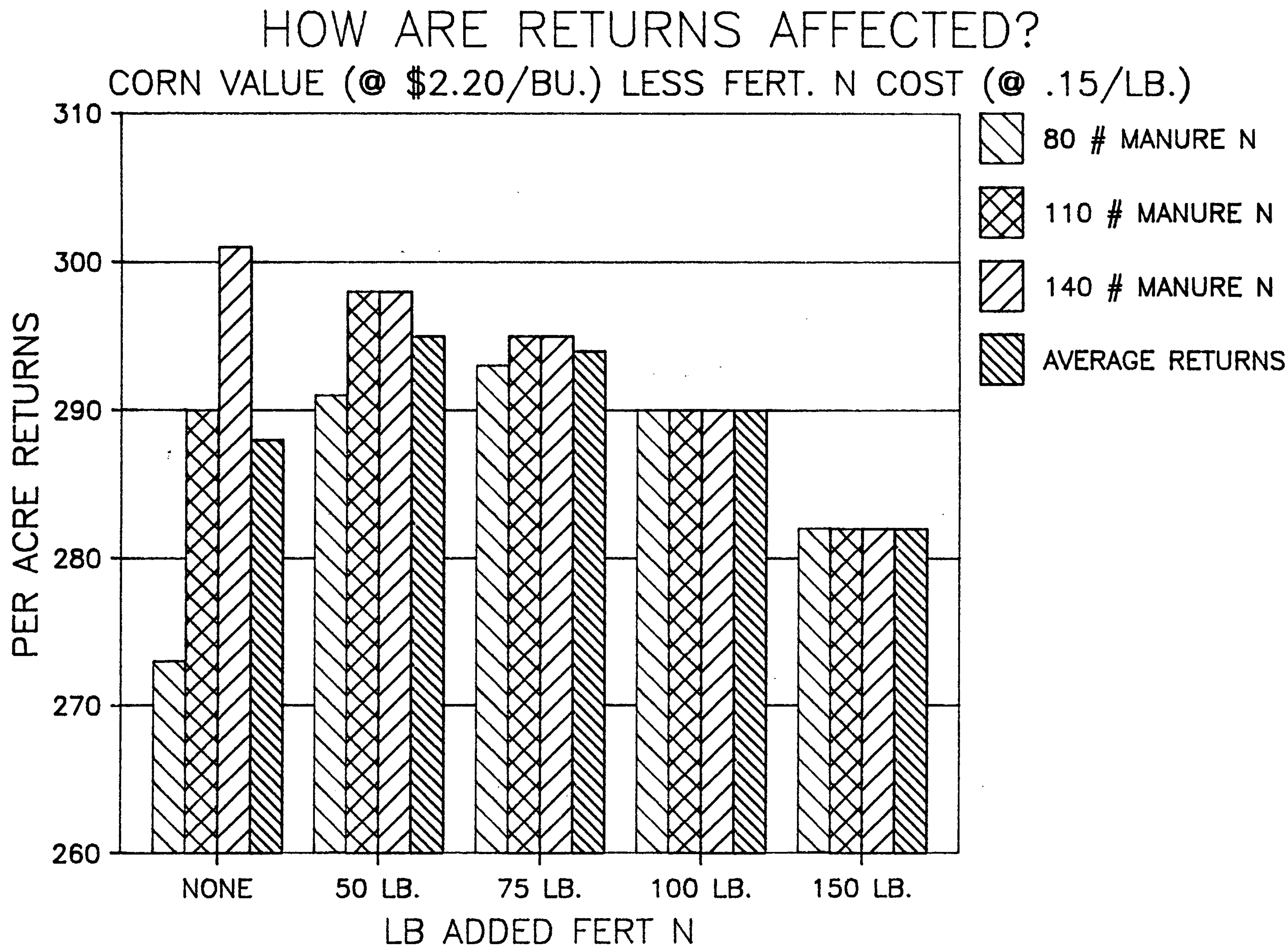
*Based on 10 years of data from Lancaster, Wisconsin yield trials.

T 3-5

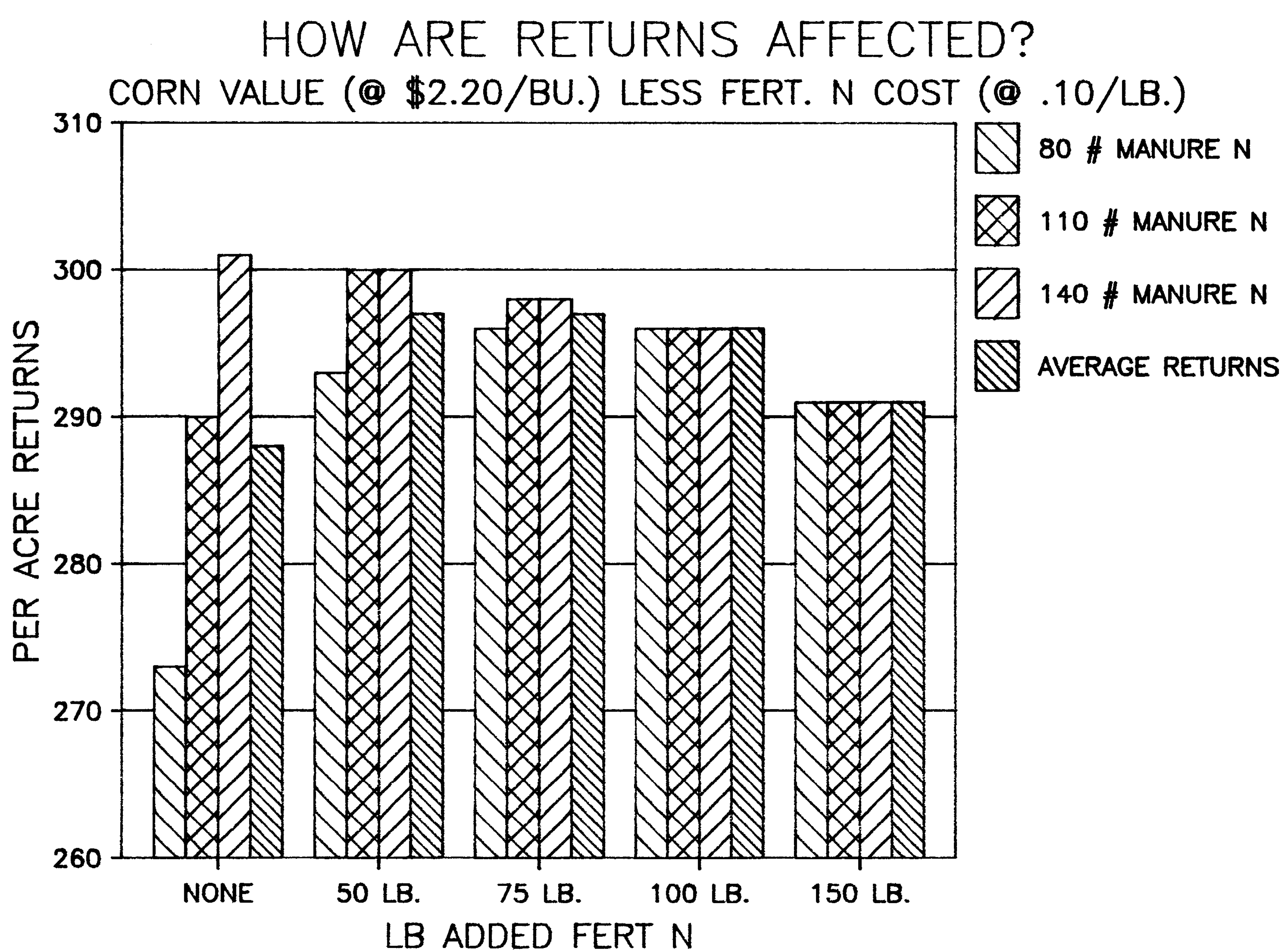
HOW DOES ADDING FERTILIZER TO THE MANURE AFFECT RETURNS??

	If you add:			
	Lb. Fertilizer N Per Acre			
(Per Acre)	None	50	75	100[4]
Corn yield (avg) if manure has:				
80 lb. N (Low manure N)	124	136	138	139
110 lb. N (Average manure N)	132	139	139	139
140 lb. N (High manure N)	137	139	139	139
Corn value (@ $2.20 bu.), with:				
Low manure N	$273	$299	$304	$306
Average manure N	$290	$306	$306	$306
High manure N	$301	$306	$306	$306
Fertilizer cost (@ .15 lb. N)	$ 0	$ 8	$ 11	$ 16
Corn value - fert. cost, with:				
Low manure N	$273	$291	$293	$290
Average manure N	$290	$298	$295	$290
High manure N	$301	$298	$295	$290
AVERAGE GROSS RETURNS	$288	$295	$294	$290

[4]150 lbs. of added fertilizer would reduce gross returns to $282 per acre regardless of the N in the manure.

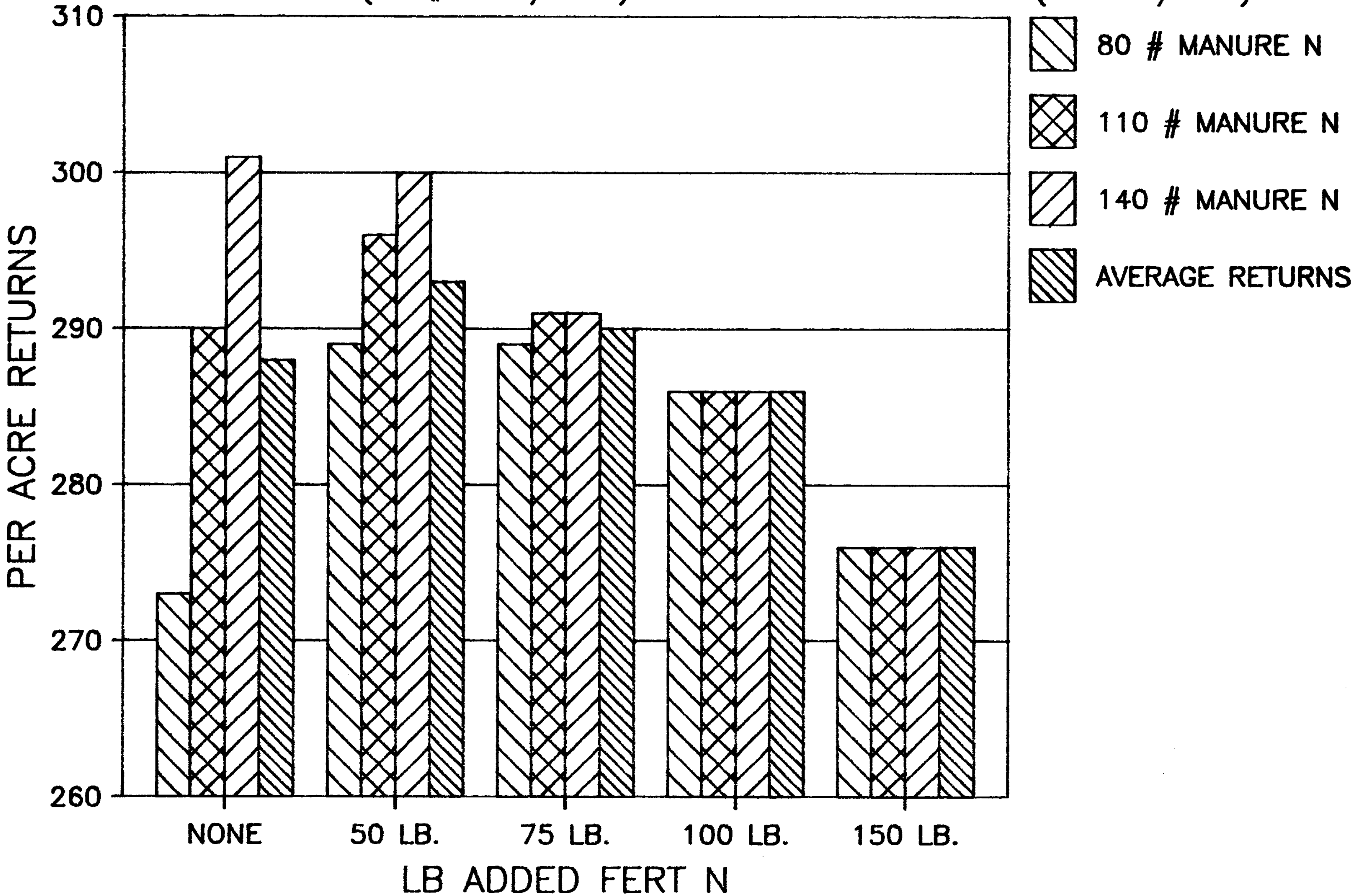


HOW ARE RETURNS AFFECTED?
CORN VALUE (@ $2.20/BU.) LESS FERT. N COST (@ .15/LB.)
PER ACRE RETURNS
310
300
290
280
270
260
NONE
50 LB.
75 LB.
100 LB.
150 LB.
LB ADDED FERT N
80 # MANURE N
110 # MANURE N
140 # MANURE N
AVERAGE RETURNS


HOW ARE RETURNS AFFECTED?
CORN VALUE (@ $2.20/BU.) LESS FERT. N COST (@ .10/LB.)
310
300
290
280
270
260
PER ACRE RETURNS
NONE
50 LB.
75 LB.
100 LB.
150 LB.
LB ADDED FERT N
80 # MANURE N
110 # MANURE N
140 # MANURE N
AVERAGE RETURNS

HOW ARE RETURNS AFFECTED?

CORN VALUE (@ $2.20/BU.) LESS FERT. N COST (@ .20/LB.)



T 3-6

MANURE, FERTILIZER, AND RETURNS

- Lower than expected nutrient availability from manure doesn't hurt yields much when at least minimal levels of fertilizer are applied.
  - Yield trials show that no fertilizer and poor manure, the yield is about 15 bu. less than the maximum yield.
  - With 50 # added fertilizer N, yield is 3 bu. less.

- The best average returns are at 50 - 75 # fertilizer N, based on this data.

- At 100 # of added fertilizer N you are throwing away money.

- At 150 # of added fertilizer N you are throwing away more money.

T 3-7

MANURE, FERTILIZER, AND "INSURANCE"

- N losses from manure can be high and do vary.

- Unpredictable actual N in manure doesn't add much unpredictability to yields.

- A bit of extra fertilizer N does provide some "insurance" against lower than expected nutrients in manure. However, it is an extra cost.

- A lot of extra fertilizer N provides no more insurance than a little, and it reduces your profits, even when the manure turns out to be low in N.

T 4-1

THE FARM

The farm is a typical SE Minnesota dairy.

Acreages:

Corn	**110**
Alfalfa and oats	**155**

Herd is 64 Holstein cows and young stock.

Nutrients in produced manure:

N	**20,000 lbs.**
P_2O_5	**8,000 lbs.**
K_2O	**16,000 lbs.**

90% of all manure is collected.

Note: This level of nutrient production is similar to typical SE Minnesota swine operations. A 120 sow farrow-finish operation or a 2100 hog finishing operation would produce similar manure N and K_2O. P_2O_5 would be 7,000 lbs. higher.

T 4-2

N FROM TWO MANURE HANDLING SYSTEMS

(lb. N)	Lined Storage		Scrape and Haul	
	Average	Range	Average	Range
N Produced	20,000		20,000	
Not collected	2,000		2,000	
Collected	18,000		18,000	
Lost through summer application (3 months)			4,500	
Lost in storage/prior to application	4,000	2,500-5,500	3,500	2,000-5,000
Available for application to corn	14,000	12,500-15,500	10,000	8,500-11,500
Lost in application:				
Broadcast			2,000	1,500-3,000
Injection	0	0-500		
Lost prior to crop use	500	0-1,000	500	500-1,000
Available to corn	13,500	11,500-15,000	7,500	5,500-9,500

N FROM TWO MANURE HANDLING SYSTEMS

SUMMARY

	Lined Storage		Scrape and Haul	
	Average	Range	Average	Range
Available to corn	13,500	11,500-15,000	7,500	5,000-9,500
% of N produced	68%	58-75%	38%	28-48%
N per corn acre:				
(110 corn acres)	123 lbs.	105-136 lbs.	68 lbs.	50-86 lbs.
Savings (if N is 0.15 per lb.)				
Per acre	55 lbs.	$ 8.25		
Per year	6000 lbs.	$900.00		

T 4-4

HOW DO THE SYSTEMS COMPARE??

The lined storage provides:

- Almost twice the usable N.
- Increased predictability of manure N (can be further increased with testing).
- Substantial fertilizer cost saving opportunities.

T 4-5

Manure storage systems and careful application increase:

- **Available N**
- **Predictability of that N**

If you own a storage system, don't waste the nutrients.

If you don't, think twice about installing one.

Factors to consider:

- **Nutrient value**
- **Labor and equipment time and expense**
- **Availability of cost sharing**
- **Environmental factors**
- **The pleasure of handling manure**

T 5-1

HOW CAN YOU ESTIMATE THE NUTRIENTS IN YOUR MANURE??

Several publications are available.

They can help you to estimate:

- **The average total nutrients (N, P, and K) in your manure.**
- **The range of N in your manure.**
- **Average and range of per acre nutrient applications.**
- **The minimum acreage required to fully utilize your manure nutrients.**
- **Appropriate levels of commercial fertilizer to add to the manure.**

Here are some helpful publications:

"Utilization of Animal Manure as Fertilizer," Minnesota Extension Service Publication AG-FO-2613.

"Manure Management in Minnesota," Minnesota Extension Service Publication AG-FO-3553.

The two publications are available for a nominal fee from:

Minnesota Extension Service Distribution Center
20 Coffey Hall
University of Minnesota
St. Paul, MN 55108

<u>Livestock Waste Facilities Handbook</u>, Midwest Plan Service Publication MPWS-18.

This is available, again for a nominal fee, from:

Midwest Plan Service
Iowa State University
Ames, IA 50011

T 6-1

1. **How do farmers' actual N (manure + fertilizer + legume) applications to manured and unmanured land compare?**

   The survey showed that on average they are over 100 lbs. per acre higher on manured land.

2. **Can farmers cut back and maintain yields?**

   Those that apply more than 180 lbs. of actual N to manured corn can. Further reductions are possible.

3. **N from manure is less predictable than fertilizer N. Doesn't that require a higher application as "insurance"?**

   Possibly a small amount higher. The key word appears to be "small".

T 6-2

4. **Do different application and storage methods affect the amount and predictability of manure N?**

   Yes. A lined liquid storage system can roughly double the N provided by a traditional scrape and haul system. The storage system reduces the variability of the N, as well.

5. **What aids are available to help you estimate the N, P, and K available on your farm?**

   A variety of publications can help.